Name of the Student:_____
Max. Marks : 17 Marks **Time : 17 Minutes**

Mark Schemes

Q1.

(a) (All matter particles) have a wave-like nature/wave-like properties ✔

Condone named particle e.g. electron
Condone 'particles have a wavelength

(and an associated) wavelength/λ = $\frac{h}{\text{momentum of the particle}}$ ✔

Condone mv for momentum
Do not allow p unless defined (eg p=mv)
Do not allow 'inversely proportional

2

(b) Use of de Broglie equation $\lambda = h / \sqrt{2meV}$ to give 0.021 nm ✔

*Allow reverse calculation to give **3800 V***
Allow 0.02 if substitution of 3500 V seen
If no other mark given allow mp1 for substitution of 3500 into equation

(Comparison of calculated value of λ to given value) and consistent conclusion ✔

Allow ecf in MP2 only for POT error.

2

(c) First Change

One statement ✔
Relevant explanation ✔

Second Change
One statement ✔
Relevant explanation ✔

Statement 1
Use target with greater spacing between atoms

Explanation
Larger separation gives rise to narrower fringes

Statement 2
Increase the p.d.
Explanation
Reduces wavelength (which gives rise to narrower fringes)

Statement 3

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Decrease distance between foil and film
Explanation
for same angles, maxima closer together.

Condone

Statement: use particles of bigger mass (e.g. protons)

smaller wavelength (at same speed)

If no other marks are awarded, give 1 mark for stating that any one of the following could change but do not allow physics errors

The target/spacing of atoms

Potential difference

Velocity of electrons

Wavelength of electrons.

Do not allow 'does not spread out as much'

Max 4

[8]

Q2.

(a) Calculation of constant of proportionality for at least two data sets ✔

Allow conversion to J

Alternative methods of calculation:

Calculation of constant of proportionality and then using to calculate other E, v, v^2 and comparing with table.

Checking ratio of $\frac{E_m}{E_n} \neq \frac{v_m^2}{v_n^2}$ *1 mark for any calculation that shows KE ≠ 1/2mv²* ✔

Calculation of at least three data sets and conclusion to the effect that as the constants differ, the classical prediction is not true ✔

If more than 3 calculations shown, reward any three correct

2

(b) v has upper limit as Ek increases✔

For MP1 allow comment on their calculations from (a) e.g. Ek/v2 increases

Do not reward references to 'constant increases'

Explanation:

As v increase mass increases✔

Treat 'exponentially' as neutral

As v approaches c, mass approaches infinity/increase in mass significant✔

Near c, increases in Ek are due to increase in mass/Ek tends to infinity✔

Condone energy/total energy for Ek

4

(c) $E_0 = m_0c^2 = 8.2 \times 10^{-14}$ J

$$E = \frac{m_0c^2}{\left(1-\frac{v^2}{c^2}\right)^{\frac{1}{2}}} = 2.6 \times 10^{-13}\ \text{J}$$

✔

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If no marks are scored 1 mark can be given for seeing 8.2×10^{-14} J
Allow ecf from MP1 for incorrect mo eg use of proton

E_k (= $E - E_0$) = $2.6 \times 10^{-13} - 8.2 \times 10^{-14}$ ✔

1.8×10^{-13} J ✔
Give all 3 marks for correct answer

3

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